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Systematic Review

Effects of physical therapy for temporomandibular disorders on headache pain intensity: A systematic review

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ABSTRACT

Background: Physical therapy is regarded an effective treatment for temporomandibular disorders (TMD). Patients with TMD often report concomitant headache. There is, however, no overview of the effect of physical therapy for TMD on concomitant headache complaints.
Objectives: The aim of this study is to systematically evaluate the literature on the effectiveness of physical therapy on concomitant headache pain intensity in patients with TMD.
Data sources: PubMed, Cochrane and PEDro were searched.
Study eligibility criteria: Randomized or controlled clinical trials studying physical therapy interventions were included.
Participants: Patients with TMD and headache.
Appraisal: The Cochrane risk of bias tool was used to assess risk of bias.
Synthesis methods: Individual and pooled between-group effect sizes were calculated according to the standardized mean difference (SMD) and the quality of the evidence was rated using the GRADE approach.
Results: and manual therapy on both orofacial region and cervical spine. There is a very low level of certainty that TMD-treatment is effective on headache pain intensity, downgraded by high risk of bias, inconsistency and imprecision.
Limitations: The methodological quality of most included articles was poor, and the interventions included were very different.
Conclusions: Physical therapy interventions presented small effect on reducing headache pain intensity on subjects with TMD, with low level of certainty. More studies of higher methodological quality are needed so better conclusions could be taken.

1. Introduction

One in five adults in Europe are estimated to have a perceived dysfunction of their masticatory system, which is related to temporomandibular disorders (TMD) (LeResche, 1997; Lövgren et al., 2016). TMDs are defined according to the Diagnostic Criteria for TMD (DC/TMD) as complaints involving the masticatory system and can be stratified into myalgia (pain in the masticatory muscles), arthralgia (pain in the temporomandibular joint), or functional complaints of the joint, like clicking or locking (Schiffman et al., 2014). Up to 85% of patients with TMD complain about myalgia (List and Jensen, 2017). Physical therapists are equipped to treat patients with these musculoskeletal complaints. In the last five years, six reviews, discuss the effectiveness of several physical therapy modalities on TMD complaints

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(Dickerson et al., 2017; Butts et al., 2017; Paço et al., 2016; Martins et al., 2016; Armijo-Olivo et al., 2016; Calixtre et al., 2015). The most recent review and meta-analysis concluded that exercise therapy is effective in reducing TMD-pain. Even though headache is a common symptom in TMD (Di Paolo et al., 2017), headache pain intensity was not taken into consideration in these reviews.

Patients with TMD report headache more frequently (68–85%) than the general population (50%) (Stovner and Andree, 2010; van der Meer et al., 2017a; Franco et al., 2010; de Leeuw and Klasser, 2013; National Center for Healt, 2016). Most common headaches in patients with TMD are Tension-Type Headache (TTH), migraine and headache attributed to TMD (van der Meer et al., 2017a; Franco et al., 2010). These headaches are classified by the International Classification for Headache Disorders 3rd edition (ICHD-3) (Headache Classification C, 2018). In contrast to the primary headaches TTH and migraine, headache attributed to TMD has a known cause for the headache complaints which is the TMD. This underlying TMD condition needs to be treated in order to decrease the headache complaints attributed to TMD. Another secondary headache that may be frequent in patients with TMD is a cervicogenic headache, as patients with TMD often report cervical dysfunction and patients with cervicogenic headache frequently report signs of a TMD (Mingels et al., 2019; Piekartz et al., 2020; von Piekartz et al., 2016).

The high co-morbidity between TMD and cervical impairments (Piekartz et al., 2020), as well as the neuroanatomical relationship between these two areas (Paparo, 2008; Castien and De Hertogh, 2019; Costa et al., 2017), may explain why physical therapy can have an effect on headache through treatment of the temporomandibular system (von Piekartz et al., 2016; Liang et al., 2019; Fernandez-de-las-Peñas et al., 2007; Bragatto et al., 2016). Besides manual physical therapy and exercise therapy, some of the common approaches for treating TMD or headache are focusing on more general aspects of pain, like pain education and counseling. This has also been found effective for patients with migraine (Kindelan-Calvo et al., 2014), TTH (Motoya et al., 2014) and TMD (Turner et al., 2006). As these physical therapy modalities may be an effective treatment for both TMD and headaches, it may be interesting to see how headache pain intensity responds to TMD-treatment. There is currently, however, no overview of the effect of physical therapy interventions for TMD on concomitant headache pain intensity. We hypothesized that TMD-treatment would have a positive effect on headache pain intensity, but that this may differ between different headaches types. Therefore, the aim of this study is to systematically evaluate the literature on the effectiveness of physical therapy interventions on concomitant headache pain intensity in patients with TMD.

2. Methods

2.1. Protocol and registration

This review has been reported in accordance with PRISMA recommendations (Moher et al., 2009) and is registered on PROSPERO (registration number CRD42017062487).

2.2. Eligibility criteria

Studies had to meet the following inclusion criteria to be eligible: 1) adult participants with TMD based on the diagnostic criteria for TMD (DC/TMD) (Schiffman et al., 2014; Dworkin and LeResche, 1992); 2) headache pain intensity as outcome measure; 3) randomized controlled trial (RCT) or controlled clinical trial (CCT); 4) TMD-treatment within the physical therapy domain (World Confederation for P, 2017); and 5) article is published in English or Dutch. Articles were excluded when an occlusal device (e.g. a stabilization splint) was the only intervention. There were no restrictions on publication dates, or on age and gender of the participants. All headache types were included in the review.

2.3. Information sources

Literature searches to identify studies were performed in the electronic databases PubMed [1966–2020], Cochrane [1993–2020] and Physiotherapy Evidence Database (PEDro) [1999–2020]. The electronic search was supplemented by snowballing of full articles retrieved. The search was conducted on August 3, 2020.

2.4. Search

Key wordsused in the search strategy were, amongst others: “physical therapy”, “physiotherapy”, “temporomandibular disorder” and “headache”. In PubMed, we used a combination of MeSH Terms and title/abstract searches and different physical therapy modalities were described. The search strategy for PEDro and Cochrane required adaptation from the PubMed search strategy. The complete search strategies can be found in Appendix 1. There was no hand search. Grey literature was not included.

2.5. Study selection

Duplicates were removed and title/abstracts of all retrieved records were screened for eligibility by two researchers blinded to each other’s results (HvdM, CMS). The full texts of the remaining articles were obtained and the full texts were assessed to see if the studies met the inclusion criteria for this review. In case of disagreement between the two reviewers, a third reviewer (RE) made the decision regarding inclusion of the article.

2.6. Data collection process, data items and summary measures

Data extraction was performed by one reviewer (HvdM). A second reviewer (LBC) checked the extracted data for accuracy. The following key data were extracted: 1) study characteristics: first author, year of publication, type of study, sample size; 2) participant characteristics: age, gender, and TMD diagnosis (Schiffman et al., 2014); 3) intervention characteristics: type of intervention(s) (World Confederation for P, 2017), frequency, and follow-up; and 4) outcome measures: intensity of headache (Headache Classification C, 2018) according to Visual Analog Scale (VAS) or similar tools and the statistical significance for both within-group and between-group analyses when available. The mean and standard deviations were extracted from the included studies for further statistical analysis.

2.7. Risk of bias in individual studies

Quality assessment of the studies was performed using the Cochrane ‘risk of bias (RoB)’ tool, in contrast with what was registered in PROSPERO, because the Cochrane RoB tool is recommended over the use of the PEDro score (Armijo-Olivo et al., 2015a). The Cochrane RoB tool assesses five domains regarding bias: selection bias, performance bias, detection bias, attrition bias and reporting bias. The tool focuses on the internal validity and does not lead to a quality score (Higgins et al., 2011). This tool shows if there is a high, low, or unclear risk of bias within the study which may influence the internal validity of the study (Higgins et al., 2011). Two independent reviewers performed the quality assessment blinded to each other’s results (HvdM, LBC). Any discrepancies were discussed and, when needed, a third reviewer (CMS) made the decision regarding the final quality score of the article. A risk of bias graph and risk of bias summary were extracted from the program Review Manager 5.3 (RevMan. Published online, 2014).

2.8. Synthesis of results and additional analyses

For each study, between-group effect sizes were calculated according to the standardized mean difference (SMD) (Hedges and Olkin, 1985), using the follow-up data. When means and standard deviations were unavailable, the first author was contacted for the details. All contacted authors provided information needed. In case only one article studied an intervention, the between-group SMD was considered. When multiple studies were available, the outcomes were pooled using Review Manager 5.3 and forest plots were provided (RevMan. Published online, 2014).

2.9. *Effect sizes were classified as small (<0.20), moderate (≥0.20 and ≤ 0.80) or large (>0.80), according to Cohen's criteria (Cohen, 1988)*

To assess the certainty of the findings, the GRADE recommendations were followed considering the following domains: trial design limitations (using the RoB tool), inconsistency of results, indirectness, imprecision of results and publication bias (Slavin, 1995; Balshem et al., 2011; Andrews et al., 2013). The certainty was classified as one of the four levels: high, moderate, low, or very low. The details of this method have been reported previously (Calixtre et al., 2015; Atkins et al., 2004; Richards et al., 2013).

3. Results

3.1. *Study selection*

The search strategy revealed 87 initial articles from PubMed, 52 from Pedro and 6 from Cochrane (see Fig. 1). After applying inclusion and exclusion criteria, five articles were included (Costa et al., 2015; Maluf et al., 2010; Michelotti et al., 2004; Michelotti et al., 2012; Piekartz and Hall, 2013). The list of excluded studies can be found in Appendix 2.

3.2. *Risk of bias within studies*

All articles received were classified as a high risk of bias on blinding of participants and personnel, and unclear risk on selective reporting (Figs. 2 and 3).

3.3. *Characteristics and results of individual studies*

In the five included RCTs (Costa et al., 2015; Maluf et al., 2010; Michelotti et al., 2004; Michelotti et al., 2012; Piekartz and Hall, 2013) the study population ranged from 28 to 54 persons (see Table 1). The follow-up period ranged from two weeks to six months. Four articles used the VAS for headache intensity as an outcome measure (Costa et al., 2015; Maluf et al., 2010; Michelotti et al., 2004; Michelotti et al., 2012). One article used a colored analog scale (CAS) to rate headache pain intensity (Piekartz and Hall, 2013). The frequency of the interventions ranged from daily for three months (Michelotti et al., 2004; Michelotti et al., 2012) to weekly for eight weeks (Maluf et al., 2010). The session time ranged from several minutes for home therapy (Michelotti et al., 2004; Michelotti et al., 2012) to full 30–40 min sessions with a therapist (Costa et al., 2015; Maluf et al., 2010; Piekartz and Hall, 2013).

Although all included studies were RCTs, there was variation in the applied protocols regarding the therapy modality and the type of control intervention.

3.4. *Effect of the interventions and level of evidence*

The GRADE criteria were applied for all therapy modalities. The studies were split in 3 subgroups, according to the intervention type and also analyzed together (Table 2 and 3). For two studies (Costa et al., 2015; Piekartz and Hall, 2013), additional data were collected from the

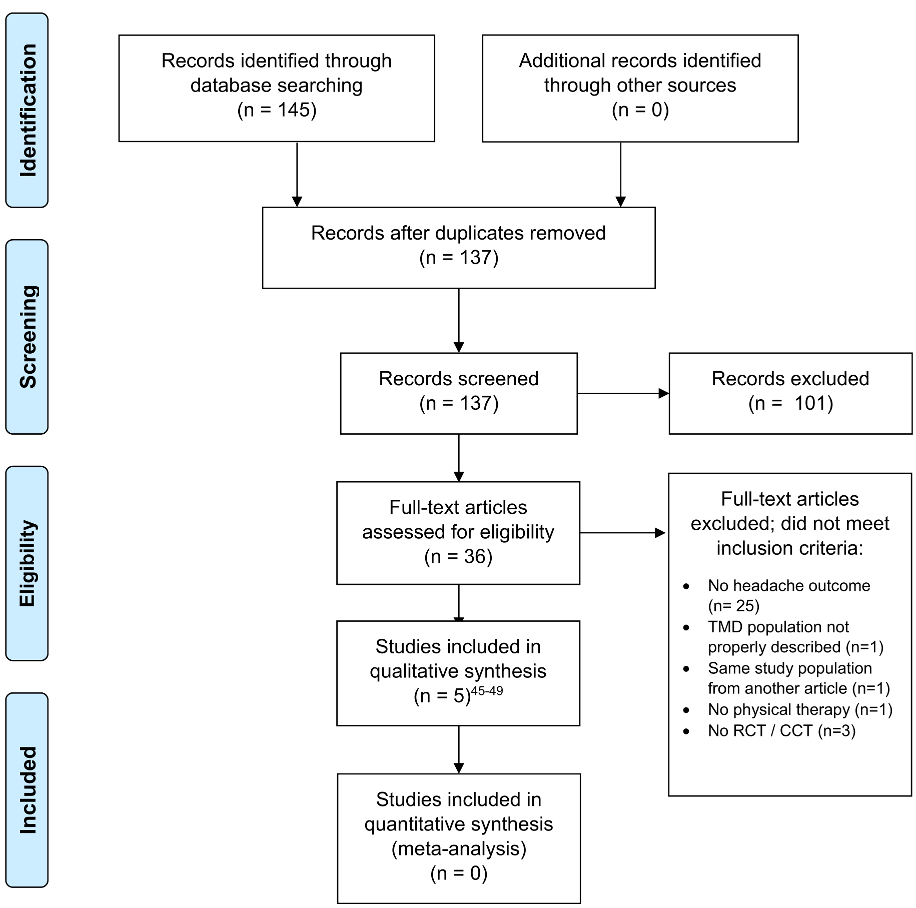

Fig. 1. Prisma flow diagra.

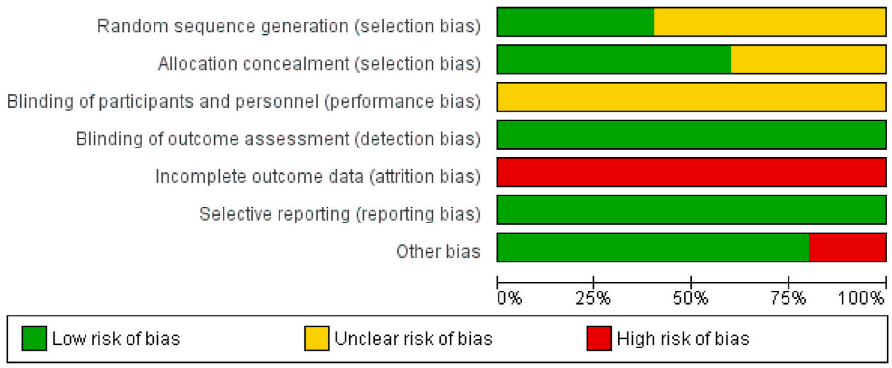

Fig. 2. Risk of bias graph.

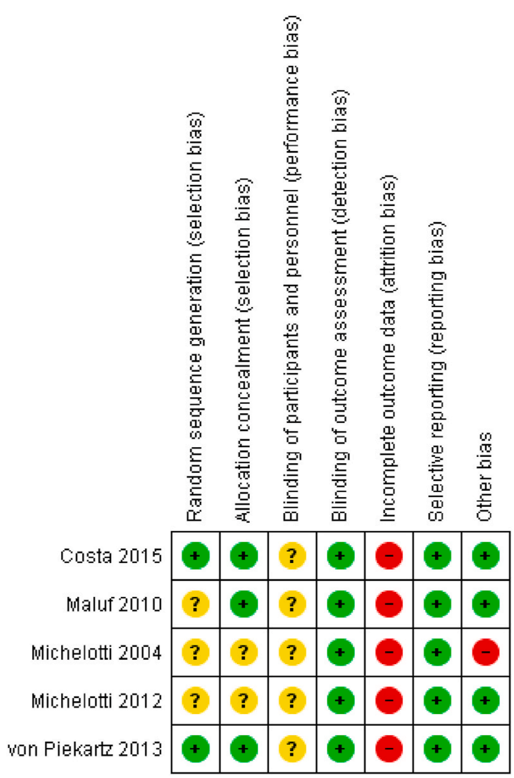

Fig. 3. Risk of bias summary.

authors to calculate the effect sizes (Table 2).

3.4.1. *Counseling and exercise versus counseling and/or splint*

Three articles studied the effect of a multimodal intervention of counseling and exercises (Costa et al., 2015; Michelotti et al., 2004; Michelotti et al., 2012). The control interventions were splint therapy (i.e. a removable artificial occlusal surface placed on the upper or lower dental arch) (Wieckiewicz et al., 2015), counseling, or a combination of both counseling and splint therapy.

On the individual analysis, there was a small between-group effect size for Costa et al. (2015) (SMD: 0.42; 95%CI: 0.09, 0.51), showing no clinically relevant difference between the multimodal therapy or combined counseling and splint therapy. The two other articles studied counseling and home exercises for three months (Michelotti et al., 2004; Michelotti et al., 2012). One study (Michelotti et al., 2012) compared education to splint therapy and showed small between-group effect size (SMD: 0.00; 95%CI: 0.59, 0.59). The other study (Michelotti et al., 2004) compared education and education combined with physical therapy for TMD. The physical therapy regimen contained self-relaxation exercises, self-massage of the masticatory muscles, application of moist heat pads on the painful muscles, stretching, and coordination exercises. There was a moderate between-group effect size (SMD: 0.05; 95%CI: 0.61, 0.51).

Fig. 4 shows the pooled mean difference, which is 0.15 (95%CI: 0.17, 0.46), indicating there is no difference in effect for counseling and exercises compared to counseling and/or splint therapy. Based on the GRADE recommendations (Table 3), we see that there is a low certainty of the found effects, downgraded by risk of bias and imprecision.

3.4.2. *Static stretching versus global stretching*

One study (Maluf et al., 2010) compared static stretching techniques for the cervical spine, upper limbs and mandibular muscles with postural reeducation. This study showed a large between-group effect size in favor of static stretching (SMD: 0.91; 95%CI: 1.76, −0.06) on reducing headache pain intensity. There is a low certainty of evidence, downgraded by risk of bias and inconsistency, that static stretching of the cervical spine, upper limbs and mandibular muscles is more effective than global postural reeducation for headache pain intensity.

3.4.3. *Orofacial and cervical manual therapy versus cervical manual therapy*

One study (Piekartz and Hall, 2013) applied orofacial therapy (i.e. jaw muscle and -joint exercises) combined with cervical manual therapy and compared this to cervical manual therapy alone. The between-group effect size was large (SMD: 1.57; 95%CI: 2.26, −0.89) showing that the intervention was superior to control intervention on reducing headache pain intensity. The level of certainty regarding the evidence was moderate, downgraded by inconsistency.

3.4.4. *Overall effect on headache by physical therapy focused on TMD*

When taking all included studies together as TMD physical therapy, this review shows that there is a very low level of certainty for TMD-treatment on reducing headache pain intensity, downgraded by high risk of bias, inconsistency and imprecision (Atkins et al., 2004). The pooled data analysis showed small overall effect (SMD: 0.12; 95%CI: 0.39, 0.16), in favor of TMD-focused physical therapy compared to control interventions (see also Fig. 5).

4. Discussion

The aim of this study was to systematically evaluate the literature on the effectiveness of physical therapy for TMD on concomitant headache pain intensity. The therapy modalities varied across the five included articles. The certainty of the findings was very low for the effectiveness of physical therapy for TMD on headache intensity.

4.1. *The influence of headache types in TMD-treatment*

Two studies described a specific headache diagnosis based on the

Table 1
Characteristics of included studies considering study design, subjects, interventions and outcome.

Author, year	Complaints	Intervention group			Control group			Therapist	Follow-up	Headache VAS outcomes				
		Population	Intervention		Population	Control intervention				Intervention group		Control group		Between group p-value
		N (%F) Age±SD	Type	Freq.	N (%F) Age±SD	Type	Freq.			B m (SD)	FU m (SD)	B m (SD)	FU m (SD)	
Costa, 2015	Myofascial TMD and headache	30 (90) 36 ± 6.7	Counseling, relaxation exercises, stretching and auto-massage jaw muscles	3–5x/week 30min for 5mo.	30 (90) 27.5 ± 6.7	Counseling and occlusal appliance	1x	Therapist (undefined)	5 months	7.6 (2.2)	4.4 (2.5)	6.5 (1.6)	3.4 (2.2)	NS
Maluf, 2010	TMD-pain	12 (100) 30.1 ± 7.1	Static stretching of cervical spine, upper limbs, and mandibular muscles	1x/week 40min for 2mo.	12 (100) 30.0 ± 4.3	Global posture reeducation	1x/week 40min for 2mo.	Therapist (undefined)	8 weeks	65.7 (21.7)	16.4 (16.6)	73.5 (26.2)	39.2 (29.8)	?
Michelotti, 2004	TMD-pain	26 (86.1) 28.2 ± 8.8	Education + home exercises	7x/week ? min for 3mo.	23 (91.2) 31.8 ± 13.0	Education	1x	Dentist	3 months	26.1 (29.7)	11.2 (17.4)	13.3 (19.7)	12.1 (17.0)	NS
Michelotti, 2012	Myogenous TMD-pain	23 (82.6) 30.2 ± 13.0	Education + home exercises	7x/week ? min for 3mo.	21 (71.4) 30.3 ± 11.4	Splint	1x	Mandibular surgeon	3 months	33.3 (19.6)	33.7 (19.2)	33.9 (21.1)	33.7 (19.2)	NS
Von Piekartz, 2013	CGH and TMD symptoms	22 (63.6) 34.7 ± 7.1	Jaw muscle and -joint exercises combined with cervical manual therapy	1–2x/week 30min for 3–6 weeks	21 (66.7) 36.1 ± 6.5	Cervical manual therapy	1–2x/week 30min for 3–6 weeks	Physical therapist	6 months	7.4[a] (1.1)	3.5[a] (2.0)	7.1[a] (1.1)	6.7[a] (1.2)	<.001

All included studies are Randomized Controlled Trials; TMD: temporomandibular disorder; CGH: cervicogenic headache; N: number of study participants; F: female; VAS: visual analog scale; m: mean; SD: standard deviation; N/A: not applicable; (?): missing; B: baseline; FU: follow-up; p: p-value; NS: not significant; mo.: months.

[a] Measured with CAS: colored analog scale.

Table 2
Between-group and within-group effect sizes for individual studies stratified for different types of physical therapy compared to control interventions.

Overall PT for TMD *versus* control interventions						
Outcome	Trial	Overall PT		Comparison		Between-group ES
		n	Within-group ES	n	Within-group ES	
Headache pain - VAS	Costa et al., 2015	30	1.34	30	1.59	0.05
	Maluf et al., 2010	12	2.46	12	1.18	0.60
	Michelotti et al., 2004	26	0.60	23	0.06	0.62
	Michelotti et al., 2012	23	−0.02	21	0.01	−0.03
	Piekartz and Hall, 2013	19	2.37	17	0.34	−2.42
Counseling and exercise *versus* counseling and/or splint therapy						
Outcome	Trial	Counseling + exercise		Comparison		Between-group ES
		n	Within-group ES	n	Within-group ES	
Headache pain - VAS	Costa et al., 2015	30	1.34	30	1.59	0.05
	Michelotti et al., 2004	26	0.60	23	0.06	0.62
	Michelotti et al., 2012	23	−0.02	21	0.01	−0.03
Static stretching *versus* global stretching						
Outcome	Trial	Static stretching		Comparison		Between-group ES
		n	Within-group ES	n	Within-group ES	
Headache pain - VAS	Maluf et al., 2010	12	2.46	12	1.18	0.60
Orofacial and cervical manual therapy *versus* cervical manual therapy						
Outcome	Trial	Orofacial + cervical manual therapy		Comparison		Between-group ES
		n	Within-group ES	n	Within-group ES	
Headache pain - CAS	Piekartz and Hall, 2013	19	2.37	17	0.34	−2.42

PT: physical therapy; TMD: temporomandibular disorder; n: number of participants; ES: effect size; VAS: visual analog scale; CAS: colored analog scale; N/A: not applicable.

Table 3
Summary of findings table according to the GRADE recommendations for studies comparing different types of PT for TMD applied to patients with TMD and headache.

Overall PT for TMD *versus* control interventions			
Outcome	N patients (studies)	Standardized Mean Difference (95%CI)	Certainty of the evidence (GRADE quality)
Headache pain - VAS	220 (5 RCTs) (Michelotti et al., 2004; Michelotti et al., 2012; Piekartz and Hall, 2013; Costa et al., 2015; Maluf et al., 2010)	−0.12 (−0.39, 0.16)	⊕◯◯◯ VERY LOW Due to risk of bias, inconsistency and imprecision.
Counseling and exercise *versus* counseling and/or splint therapy			
Outcome	N patients (studies)	Standardized Mean Difference (95%CI)	GRADE quality
Headache pain - VAS	153 (3 RCTs) (Michelotti et al., 2004; Costa et al., 2015; Michelotti et al., 2012)	0.15 (−0.17, 0.46)	⊕⊕◯◯ LOW Due to risk of bias and imprecision.
Static stretching *versus* global stretching			
Outcome	N patients (studies)	Standardized Mean Difference (95%CI)	GRADE quality
Headache pain - VAS	24 (1 RCT) (Maluf et al., 2010)	−0.91 (−1.76, −0.06)	⊕⊕◯◯ LOW Due to risk of bias and inconsistency.
Orofacial and cervical manual therapy *versus* cervical manual therapy			
Outcome	N patients (studies)	Standardized Mean Difference (95%CI)	GRADE quality
Headache pain - CAS	43 (1 RCT) (Piekartz and Hall, 2013)	−1.57 (−2.26, −0.88)	⊕⊕⊕◯ MODERATE Due to inconsistency.

GRADE: Grades of Recommendation, Assessment, Development, and Evaluation; PT: physical therapy; TMD: temporomandibular disorder; n: number of participants; VAS: visual analog scale; CAS: colored analog scale.
* Methodological quality limitations based on the Cochrane Risk of Bias tool (high risk: serious −1 or very serious −2; unclear risk; not serious or serious −1). **GRADE Working Group grades of evidence High certainty:** We are very confident that the true effect lies close to that of the estimate of the effect **Moderate certainty:** We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different **Low certainty:** Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect **Very low certainty:** We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect.

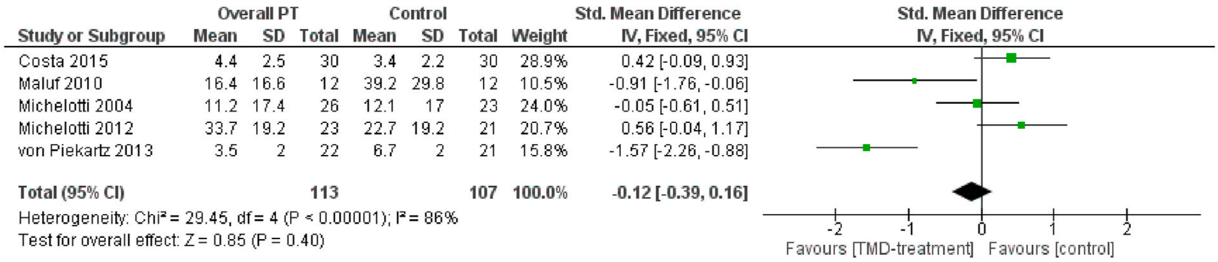

Fig. 4. Forest plot of comparison overall physical therapy versus control interventions.

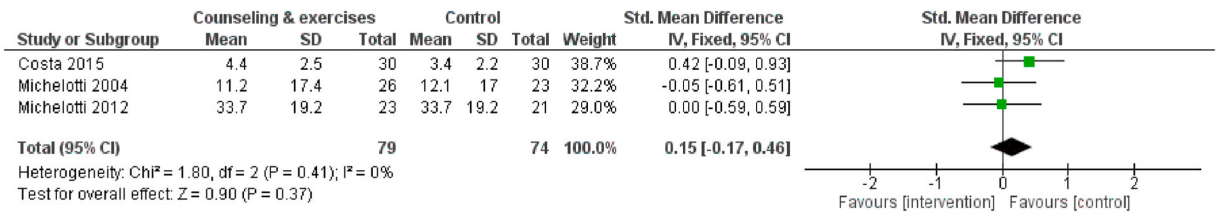

Fig. 5. Forest plot of comparison counseling and exercises versus counseling and/or splint therapy.

ICHD-II, which were headache related to masticatory myofascial pain and cervicogenic headache (Costa et al., 2015; Piekartz and Hall, 2013; Headache Classification S, 2004). The other three studies did not describe the headache types (Maluf et al., 2010; Michelotti et al., 2004; Michelotti et al., 2012), but they may have been at least a part of patients with primary headache as these are very prevalent (10–63%) in patients with TMD (Di Paolo et al., 2017; Franco et al., 2010; van der Meer et al., 2017b; Goncalves et al., 2011). The presence of a primary headache may have negatively interfered with the efficacy of the different musculoskeletal TMD treatments on TMD complaints (Porporatti et al., 2015). This is possibly due to peripheral or central mechanisms. For instance, one theory states that the increase in pain transmission from peripheral tissues, such as the masticatory system, to the trigeminal system negatively interferes with the efficacy of the treatment (Porporatti et al., 2015). Central sensitization (CS) can also play a role in the efficacy of treatment, as patients with multiple complaints such as chronic TTH, migraine and TMD tend to show more signs of CS (Costa et al., 2017; Campi et al., 2017; Woolf, 2011; La Touche et al., 2018). Patients with signs of CS manifest pain hypersensitivity and hyperalgesia, for whom certain therapies may increase the pain rather than decrease it (Woolf, 2011; Louw et al., 2017). A combination of peripheral and central mechanisms can also contribute to the etiology and interference with therapy: input from the periphery (i.e. masticatory system) may turn to painful output due to CS (Woolf, 2011; La Touche et al., 2018). However, combining a TMD treatment with specific medication for migraine is found to be more effective as compared to a single treatment for either TMD or migraine (Goncalves et al., 2013). Thus, it is important to know which type of headache is the concomitant headache with the TMD complaints.

4.2. The role of the muscles and the cervical spine

In this review, two studied interventions (stretching and orofacial therapy) focused on myogenous problems rather than arthrogenous (Maluf et al., 2010; Piekartz and Hall, 2013). Headache is more prevalent in patients with muscle-related TMD than in patients with joint-related TMD (van der Meer et al., 2017a; Goncalves et al., 2011; Ballegaard et al., 2008), and some headaches, for example TTH, are similar to certain muscular referred pain patterns (Bendtsen and Fernández-De-La-Peñas, 2011; Fernández-pérez et al., 2012). This may explain the effectiveness of the muscle-oriented physical therapy for TMD on headache intensity. Both stretching and orofacial therapy aim at relaxing the muscles and by that decreasing the TMD-pain and headache pain intensity (Maluf et al., 2010; Piekartz and Hall, 2013). Additionally, both studies showed that combining treatment regarding the temporomandibular area (jaw, masseter muscle, temporal muscle) and cervical area (spine and muscles) are effective for headache intensity (Maluf et al., 2010; Piekartz and Hall, 2013).

Other studies have also shown that exercises for the cervical spine can decrease both TMD complaints as well as headache complaints (Calixtre et al., 2015; Calixtre et al., 2019; Madsen et al., 2018; Castien et al., 2011). Three studies included applied home exercises as part of the physical therapy for TMD (Costa et al., 2015; Michelotti et al., 2004; Michelotti et al., 2012). However, it is unclear which specific home exercises were applied and if they were only addressed to the jaw or also the cervical spine. Furthermore, there is debate about the effectiveness of home exercises compared to supervised exercises. For other disorders such as knee osteoarthritis, chronic neck pain and shoulder impingement, both types of exercise were effective, but when at least one supervised training was done the effect increased and lasted longer (Deyle et al., 2005; Evans et al., 2012; Granviken and Vasseljen, 2015). Future studies should describe the types of exercises more elaborately and compare supervised exercises with home exercises to fully understand how to apply exercise therapy for best results.

As patients with TMD pain often experience pain or dysfunction in the cervical spine (Piekartz et al., 2020; Visscher et al., 2001) and patients with headache also often experience neck problems (Ashina et al., 2015), it is important to not just look at the masticatory system in patients with TMD and headache, but also include the cervical spine and muscles (Costa et al., 2017). Bruxism may also play a role in this three-way association, as temporomandibular disorders, cervical impairment and headaches are all associated with bruxism (van der Meer et al., 2017a; Piekartz et al., 2020; Fernandes et al., 2013; Baad--Hansen et al., 2019). When patients are bruxing, not only their masticatory muscles are active but also muscles from the cervical spine (Gouw et al., 2020). Currently the exact working mechanism on these four aspects and how they influence each other and treatment outcomes remains unclear. Therefore, more high-quality research is needed to establish the association between TMD, headache and cervical involvement and the effects of treating these complaints separately compared to treating them simultaneously.

4.3. Strengths and limitations of the study

There are several strengths in this review. First, this review is the first study to approach the issue of the effect of treating TMD on headache pain intensity. By describing the limitations per study, a clear suggestion for future research can be made. Secondly, all steps within this review have been done by two researchers, blinded to each other's results.

However, the results of this review must be interpreted considering some limitations. First, when interpreting the pooled results one should consider that these are based on a heterogeneity of interventions, patient populations, and therapists. Furthermore, most included studies scored a high or unclear risk of bias on allocation concealment. A meta-epidemiological study stated that this bias may exaggerate treatment effects (Armijo-Olivo et al., 2015b). As blinding of participants or therapists in physical intervention studies is near impossible to have, most studies scored poorly on these aspects. Also, the interventions studied in this review could all be given by a physical therapist and are part of the physical therapy modalities, but were sometimes given by undefined therapists (Costa et al., 2015; Maluf et al., 2010), by a dentist (Michelotti et al., 2004), or a mandibular surgeon (Michelotti et al., 2012). Physical therapists are experts in the musculoskeletal field and are equipped to apply interventions to promote movement, reduce pain, restore function and prevent disability, just as the interventions within this review (APTA, 2015). If these interventions would have been applied to the patients by physical therapists, the outcomes may have been different. Most preferably, a collaboration between different disciplines should be applied in the future for optimal results (Rocabado et al., 1982; Gaul et al., 2011). For the current review, the findings should be interpreted with caution as there was not a physical therapist involved in each study, but contained other disciplines or home exercises, so a full conclusion of the effectiveness of physical therapy cannot be given. Furthermore, this review did not include chiropractic or osteopathic interventions in the search. Even though all three professions work with musculoskeletal complaints and could therefore be applied within the same review, they all require different educational degrees and are therefore not interchangeable. Thus, they were not included in the review, but it may be interesting for future studies to look at the effectiveness of those interventions on headache pain intensity in patients with TMD. Finally, there were only two studies that specified which headache type the patients were diagnosed with (Costa et al., 2015; Piekartz and Hall, 2013). As different headache types have different etiologies, treatments may have a different effect on each headache type (Headache Classification C, 2018).

4.4. Implications for research

Although it is impossible to blind the therapist in hands-on and counseling studies, intention-to-treat and blinding of subjects are possible but were not used in the included studies. We suggest that future studies should include placebo or sham groups as a comparison so the placebo effect of those therapies can be explored (de Morton, 2009; Castro, 2007). If this is not possible, future studies should compare two distinct interventions to establish the effect of one intervention compared to the other. Furthermore, intention-to-treat analysis should be used more consequently, to reduce bias and increase the quality of methodology and the level of evidence (Higgins et al., 2011; de Morton, 2009). Future studies should also report the headache diagnosis of the patients, as it is very likely that the effect of TMD-treatment on primary headaches is different as compared to the effect on secondary headaches. More research needs to be done to establish the role primary headache may have in the effectiveness of TMD treatment (van der Meer et al., 2017a; Franco et al., 2010; Goncalves et al., 2011). Additionally, the treatment protocol needs to be available so physical therapists can apply the treatment methods in the clinical practice when the therapy is effective.

4.5. Implications for clinical practice

As multiple factors play an important role in the etiology of both TMD and headache, it is important for therapists to define these factors before starting treatment (Schiffman et al., 2014; van der Meer et al., 2017a; Headache Classification C, 2018; Gaul et al., 2011; Dekker-Bakker et al., 2008). Because this review has not shown clear evidence for all physical therapy modalities, physical therapists must consider which treatment to apply based on the beforementioned factors. As orofacial physical therapy and cervical manual therapy do appear to be effective to reduce headache pain intensity, a specialized physical therapist should be part of the health care team for the treatment of TMD and headache, although they may not be available in all countries (Piekartz and Hall, 2013; Gaul et al., 2011; Dekker-Bakker et al., 2008).

5. Conclusion

Due to the methodological shortcomings, diversity of interventions and inconsistency of findings, there is currently a very low certainty that there is an effect of physical therapy for TMD on concomitant headache intensity compared to control interventions.

Conflicts of interest

There is no conflict of interest within this study.

Ethical approval

Not applicable.

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Not applicable.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.msksp.2020.102277.

5). Registration

The review is registered on PROSPERO (registration number CRD420170624).

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